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(54) FIBER MADE FROM COPOLYMERIZED POLYESTER COMPOSITION

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## CLAIMS

1. A fiber made from a copolymerized polyester composition consisting of a copolymerized polyester made from an acid component consisting of more than 50 mol% of terephthalic acid, more than 70 mol% of ethylene glycol + 1,4-butanediol + 1,6-hexanediol, and 0-45 mol% of an aliphatic and/or alicyclic copolymerization component other than ethylene glycol, 1,4-butanediol, and 1,6-hexanediol and having a melting point of 80-200°C, crystal heat of fusion above 2.0 cal/g, minimum crystallization time of less than 90 sec, and polyethylene terephthalate adhesion shear strength above 5 kg/cm<sup>2</sup>, as well as a copolymer made from an  $\alpha$ -olefin and an unsaturated carboxylic acid mono- or divalent metal salt.

2. A composite fiber made from the copolymerized polyester composition according to Claim 1 and a thermoplastic polymer with a melting point above 150°C and a fiber cross section circumference fraction formed by the composition, above 40%.

## DETAILED EXPLANATION OF THE INVENTION

The present invention concerns a polyester-based thermally bondable fiber, and it is an objective of the present invention to provide fibers that have excellent thermal bonding properties and show no problems in making fibers and fiber bundles using the fiber.

Thermally bondable fibers for making nonwoven fabrics, etc., by thermal bonding between fibers have been known, e.g., composite fibers with polypropylene using polyethylene as the bonding component, composite fibers with polyethylene terephthalate using vinyl alcohol copolymers as the bonding component, etc.

Recently, in the fiber field, especially in the nonwoven fabric field, the role of polyester fibers, mainly polyethylene terephthalate (hereafter referred to as PET) became very large; in terms of production efficiency, energy conservation, etc., the demand for making fiber bundles and fiber products, especially nonwoven fabrics, by thermal bonding is high, and bonding fibers for polyesters are strongly desired.

While such known bonding fibers result in good bending between the bonding polymers themselves, when used together with other main fibers in nonwoven fabrics, the type of main fibers capable of bonding is rather limited, and nothing is bondable with polyesters. For example, polyethylene is good with respect to self-bonding, while it does not bond with ordinary commercially available fibers with different chemical structures. While copolymerized nylons bond to nylon fibers, they do not bond to polyester fibers, which are similar condensation

polymers. Furthermore, ethylene-vinyl alcohol copolymers bond to rayon, vinylon, or nylon having relatively similar solubility parameters, but do not bond to polyesters.

For bonding polyester fibers, using polyesters with similar chemical structures and solubility parameters as the bonding component is considered common sense. Actually, many copolymerized polyesters have been proposed for solvent-based or hot-melt adhesives for bonding polyesters.

However, when copolymerized polyesters are used as bonding fibers, in making fibers or nonwoven fabrics, special devices and a unique thermal history are utilized, thus the usual copolymerized polyester bonding agents cannot be used at all.

For example, when molten polymers are extruded through a spinneret to form fiber bundles collected in a can or fibers wound on a bobbin, fusion between fibers or fiber bundles is severe and spun fibers are very difficult to obtain.

In subsequent drawing, crimping, cutting, etc., further fusion occurs, and obtaining good fibers is not possible. In particular, when fiber bundles with a large total denier are made for increased productivity, problems in the fiber making process become further pronounced. If fiber forming is done incompletely, e.g., in forming nonwoven fabrics, card passing is poor and tackiness problems may be encountered in the bonding treatment, making nonwoven fabric production impossible. The processability required in spinning and subsequent fiber formation and nonwoven fabric production is very strict, and even when there are no problems in recovering the molten polymer from the polymerization bath, making chips by cutting into pellet form, drying of the pellets before feeding them into an extruder directly connected to the spinning machine, fiber formation, and nonwoven fabric formation may not be done.

On the other hand, in some cases of copolymerized polyesters, if the degree of modification is small because of a reduced copolymerization component content, the fiber or nonwoven fabric production process may be good but, in general, adhesive properties with respect to PET or polybutylene terephthalate (hereafter referred to as PBT), which are currently produced on a large commercial scale, are small, and they cannot be used for bonding fibers.

As a result of various studies on fibers having excellent bonding to polyesters and good processability in fiber or nonwoven fabric production, we have discovered that copolymerized polyesters with certain compositions and properties that are entirely different from those of adhesives are suitable.

Namely, we have discovered that copolymerized polyesters consisting of a copolymerized polyester from an acid component consisting of more than 50 mol% of terephthalic acid (TA), more than 70 mol% of ethylene glycol (hereafter referred to as EG) + 1,4-butanediol (hereafter referred to as BD) + 1,6-hexanediol (hereafter referred to as HD), and 0-45 mol% of an aliphatic and/or alicyclic copolymerization component other than EG, BD, and HD

and having a melting point of 80-200°C, crystal heat of fusion ( $\Delta H_u$ ) above 2.0 cal/g, minimum crystallization time (hereafter referred to as  $CT_{min}$ ) of less than 90 sec, and PET adhesion shear strength (SS) above 5 kg/cm<sup>2</sup> provide good adhesive properties as well as good processability.

However, in industrial production, processability requirements in fiber production, etc., are very strict, and a very high level is desired. Namely, reaching a certain level in small prototype production in a short time, prototype production with the addition of various conditioning agents, prototype product formation under special conditions, etc., in terms of process passage and qualities may not be sufficient, and long-term production stability under a wide range of conditions is necessary. In this sense, the copolymerized polyesters described above are not satisfactory, and further improvements are needed.

As a result of various investigations concerning stability improvements in the process and qualities, we have discovered that the problems described above can be completely overcome for the first time with copolymerized polyester compositions consisting of the copolymerized polyesters described above and copolymers made from  $\alpha$ -olefins and unsaturated carboxylic acid mono- or divalent metal salts, and bonding fibers with good bonding properties and excellent process stability can be obtained.

It has been known that the surface appearance of molded products can be improved by adding the copolymers of the present invention to reinforced PET. It has also been known that they are added to polyester resin compositions for metal coating for improving adhesion to the metal and fabrication processability of the coated metal plates. However, it has not been known at all that fibers having good adhesive properties as well as good processability can be obtained from certain copolymerized polyesters defined in the present invention and copolymer compositions of the present invention. For obtaining fine fiber forms, a very strict processability is needed, as compared to the usual resin moldings, and investigations in different areas are needed. It has been discovered that good fibers can be obtained only with the combined compositions of the present invention.

In the present invention, in the copolymerized polyester, based on the total acid component in the polyester formed (in the case containing oxy acids, one-half the acid component and one-half the diol component), in the copolymerization composition (hereafter, the copolymerization composition is given in mol% based on the total acid component), TA is above 50 mol%, preferably above 60 mol%, and more preferably above 70 mol%. With TA below 50 mol%, the fiber qualities and processability are not good, and the cost is not desirable.

In the copolymerized polyesters of the present invention, the total of EG, BD, and HD is above 70 mol%, preferably above 75 mol%, and more preferably above 80 mol%. With this total below 70 mol%, the physical properties are not desirable, leading to reduced fiber qualities and processability, and with a disadvantageous cost.

Furthermore, in the copolymerized polyesters of the present invention, aliphatic and/or alicyclic copolymerization components other than EG, BD, and HD are present at 0-45 mol%, preferably 3-41 mol%, and more preferably 6-37 mol%. A higher number of moles is good for the nonwoven fabric adhesive properties and handle, but above 45 mol% results in a reduced processability, thus not favored.

The aliphatic and/or alicyclic copolymerization components other than EG, BD, and HD result in a reduced melting point and hardness. Preferred are those causing minimum crystallinity lowering, and those that are symmetric and have no bulky pendent chain are desirable. However, these are not limiting factors, and depend on the physical properties desired.

Specific examples of such components include adipic acid, sebacic acid, hydroxyacetic acid, trimethylene glycol, pentamethylene glycol, diethylene glycol, triethylene glycol, polyethylene glycol, cyclohexanedimethanol, propylene glycol, neopentyl glycol, etc.

While the copolymerized polyesters that can be used in the fibers of the present invention have to satisfy the compositional conditions described above, the following properties have to be retained for assured qualities of commercial-scale production fibers, nonwoven fabric production-process stability, bonding fibers, and nonwoven fabrics.

Namely, the copolymerized polyesters of the present invention should have a melting point of 80-200°C, preferably 90-185°C, and more preferably 100-175°C. With the melting point below 80°C, fibers and nonwoven fabrics do not have a satisfactory heat resistance, etc., i.e., not good for practical applications. On the other hand, with the melting point above 200°C, a high temperature is needed for bonding, conventional apparatuses cannot be used, and even when a high-temperature treatment apparatus is used, the molded products may be deformed with a poor handle, possibly with a high energy loss, thus not favored.

Furthermore, the copolymerized polyesters of the present invention should have a crystal heat of fusion ( $\Delta H_u$ ) above 2.0 cal/g, preferably above 2.5 cal/g, and more preferably above 3.0 cal/g. Below 2.0 cal/g, fusion occurs easily during fiber production, thus not favored. For  $\Delta H_u$  measurement, the molten polymer is made into a fine fiber or thin film, cooled, allowed to stand at room temperature for more than 3 days, then run on a differential scanning calorimeter (DSC) in nitrogen at a heating rate of 10°C/min;  $\Delta H_u$  is obtained for the endothermic peak area in fusion.

Also, the copolymerized polyesters of the present invention should have a minimum crystallization time ( $CT_{min}$ ) of less than 90 sec, preferably less than 70 sec, and more preferably less than 50 sec. Above 90 sec, fusion occurs easily during fiber formation.

$CT_{min}$  is the time for initiation of whitening when a small essentially nonoriented film piece is placed in a silicone or water bath at a certain temperature and [is] the crystallization time at a temperature at which the crystallization initiation time is shortest in the range of 0-120°C.

While  $CT_{\min}$  may be measured in air rather than in a bath, measurement in the bath is preferred for a high heat exchange rate with minimal effects in the cooling process. In the present invention, the values measured in a bath are used. For obtaining  $CT_{\min}$ , it is not necessary to measure  $CT_{\min}$  at various temperatures, and a crystallization time of less than 90 sec at a temperature in the 0-120°C range is satisfactory. The temperature showing  $CT_{\min}$  can be near 0°C or 120°C. Actually, the crystallization time in the fiber manufacturing process varies according to the thermal history, etc., and once the temperature exhibiting  $CT_{\min}$  is set, the crystallization speed in the process can be fast, of course. Sometimes, in spinning, the crystallization speed increases if the fiber is oriented, while the  $CT_{\min}$  defined in the present invention can be used as a measure related to processability.

The copolymerized polyesters of the present invention should have a PET film adhesion shear strength (hereafter referred to SS) above 5 kg/cm<sup>2</sup>, preferably above 6 kg/cm<sup>2</sup>, and more preferably above 7 kg/cm<sup>2</sup>. Below 5 kg/cm<sup>2</sup>, the fiber adhesion strength, especially the nonwoven fabric strength, is not sufficient, thus not favored.

For SS measurement of the present invention, a 0.3-mm-thick copolymerized polyester film and a biaxially stretched PET film (trademark: Diafoil, thickness 0.1 mm, product of Mitsubishi Jushi) were melted by heating to a temperature 20°C higher than the copolymerized polyester melting point, pressed under a pressure of 5 kg/cm<sup>2</sup> for bonding, conditioned at 20°C and relative humidity of 65% for 24 h, and measured for shear strength at a tensile rate of 20 cm/min.

The copolymerized polyester or its compositions of the present invention may also contain small amounts of additives such as deglossing agents like titanium oxide, etc., antioxidants, fluorescent whiteners, stabilizers, UV absorbers, etc.

The  $\alpha$ -olefin-unsaturated carboxylic acid mono- or divalent metal salt copolymers compounded with the copolymers of the present invention are so-called ionomers. There are many carboxylic acid metal salt compounds and polymers containing carboxylic acid metal salts, but many of them form impurities in the compositions, cause fiber breakage during spinning or drawing, discolor the compositions, provide no improvements in processability, or reduce the adhesive properties; only the ionomers of the present invention provide fibers with good qualities such as adhesive properties, etc., and processability.

Specific examples of ionomers include ethylene copolymers with acrylic acid, methacrylic acid, maleic acid, or itaconic acid, in which a portion or all of the carboxy groups is in the salt form with mono- or divalent metals such as sodium, potassium, lithium, zinc, magnesium, calcium, etc. The unsaturated carboxylic acid monomer content in the ionomers should be 0.7-25 mol%, preferably 1.0-20 mol%, with the degree of neutralization of the carboxyl group being 10-100%, preferably 15-80%. Examples of commercially available

ionomers are Surllyn of the DuPont Co., Himilan of Mitsui Polychemical Co., Corpolene of Asahi Dow Co., etc.

The ionomer content in the overall composition should be 0.5-20%, preferably 1-15%, and more preferably 2-10%. Below 0.5%, the desired effects are not sufficient, while above 20% the adhesive property is too low, with a reduced processability, thus not favored.

For compounding, the ionomers of the present invention are added to the polymerization apparatus during or after the polymerization of the copolymerized polyesters. However, depending on the polymerization conditions and compounding conditions, unmixed impurities may be formed or discoloration may occur. Thus, it is preferred that they are mixed in pellet form or melt form before spinning.

The copolymerized polyester properties in the case of being compounded with ionomers before completion of the polymerization reaction include the properties of the copolymerized polyester alone in the composition and those after completion of the polymerization near the  $[\eta]$  value with correction of the ionomer content.

Although it is preferred that the fibers from the compositions of the present invention as well as fiber bundles and nonwoven fabrics made from such fibers are prepared using optimum unique machines and apparatuses, conventional machines and apparatuses can also be used without substantial modification. The present invention is really significant in that the fibers can be made using conventional machines and apparatuses.

The fibers of the present invention can be made from only the compositions of the present invention (homofilaments), while the compositions can also be spun with other melt-spinnable polymers to obtain composite fibers.

The other composite fiber components are thermoplastic polymers having a melting point above 150°C, e.g., PET, PBT, nylon 6, nylon 66, polypropylene, etc. When used for bonding fibers, the portion occupied by the copolymerized polyester-containing composition component in the overall peripheral length of the composite fiber cross section, i.e., fiber cross-sectional circumference fraction, is preferably above 40%.

While the fibers of the present invention can be used as modified fibers, it is very favorable to use these fibers for bonding at a temperature above the fiber softening point. The fibers of the present invention can be used for bonding fiber bundles of the homofilaments of the copolymerized polyester composition alone or as composite fibers with other polymers, while they can also be used as mixed bonding fiber bundles consisting of 10 wt% or more of these fibers and other fibers.

Fiber bundles are especially suitable for obtaining nonwoven fabrics with high strength. When the fibers mixed are TA-containing polyesters such as PET or PBT, good bonding is obtained not only between the bonding fibers, but also with the TA-based polyesters, resulting in

high-strength nonwoven fabrics. There have not previously been fibers bonding to TA-based polyesters, thus the present invention is very significant in enabling the production of good polyester nonwoven fabrics.

Next, the present invention is explained with examples.

In the examples, the moles indicating the copolymer composition amount is mol% based on the overall acid component of the polyester to be formed.

The  $[\eta]$  value is the limiting viscosity (dL/g) measured at 30°C for the polyester in a 1:1 mixture of phenol and tetrachloroethane.

The polyester melting point (m.p.) was measured for samples on a hot plate by a melting-point measurement device for micro-samples as the point at which polarized light disappears or the flow point.

For the nonwoven fabric strength measurement, 20 parts by weight of bonding fibers and 80 parts by weight of PET fibers (3 d x 51 mm) were carded, formed into a web, pressed under a pressure of 10 kg/cm<sup>2</sup> for 1 min with melting of the bonding fibers for thermal bonding, and the resulting nonwoven fabric was measured for the breaking length (km).

#### APPLICATION EXAMPLE 1

Pellets of a copolymerized polyester consisting of 60 mol of TA, 100 mol of BD, and 40 mol of sebacic acid and having  $[\eta]$  of 1.10, m.p. of 153-156°C,  $\Delta H_u$  of 3.5 cal/g, room-temperature crystallization time of 3 sec, and SS of 14.0 kg/cm<sup>2</sup> were compounded with pellets of Surlyn 1555 (an ionomer from the DuPont Co., a copolymer of ethylene with about 2 mol% of methacrylic acid, with about 2/3 of the carboxy groups being neutralized by sodium) at an ionomer content of 5 wt% based on the sum of the copolymerized polyester and ionomer (hereafter, the compounding amount is wt% based on the overall composition), fed into an extruder, extruded through a spinneret having 100 orifices of 0.4 mm diameter at a spinning head temperature of 240°C, and the fiber was wound at a rate of 800 m/min. The wound fiber showed no fusion between individual filaments and between bundles, and the spinning could be continued in a stable manner for a long period of time.

The fiber thus obtained was drawn at 80°C at a draw ratio of 3.4:1, allowed to shrink 15% in 90°C water, crimped in a stuffing box, and cut to obtain a fiber with a fineness of 3.3 dr (denier), strength of 3.5 g/d, and elongation of 52%.

A high-strength nonwoven fabric with a breaking length of 4.9 km was obtained from a mixture of 20 parts by weight of the copolymerized polyester fiber and 80 parts by weight of PET fiber. There were no problems in making the nonwoven fabric.



## APPLICATION EXAMPLE 2

Composite spinning was carried out using a sheath component consisting of the copolymerized polyester of Application Example 1 and Surlyn 1555, along with a PET core with  $[\eta]$  of 0.67 at a core/sheath weight ratio = 40/60 at a spinning head temperature of 290°C and fiber winding speed of 800 m/min. The wound fiber showed no fusion between individual filaments or between fiber bundles, and stable continuous spinning was possible.

The fiber thus obtained was drawn at 80°C at a draw ratio of 3.7:1, allowed to shrink 15% in 90°C water, crimped in a stuffing box, and cut to obtain a fiber with a fineness of 3.2 dr, strength of 3.8 g/d, and elongation of 51%.

A high-strength nonwoven fabric with a breaking length of 4.4 kg was obtained from a mixture of the composite fiber and PET fiber. There were no problems in making the nonwoven fabric.

## COMPARATIVE EXAMPLE 1

Without adding the ionomer, the copolymerized polyester of Application Example 1 was spun at a spinning head temperature of 240°C and winding speed of 800 m/min, showing severe fusion between individual filaments and fiber bundles, thus good fibers were not obtained. Also, at the spinning head temperature of 200°C, the polymer extrusion was unstable, and fusion between fibers was severe.

## COMPARATIVE EXAMPLE 2

Composite spinning was carried out using the copolymerized polyester of Comparative Example 1 for the sheath and PET with  $[\eta]$  of 0.67 for the core at a core/sheath weight ratio = 40/60 at a spinning head temperature of 275°C varied to 290°C, and winding speed of 800 m/min. Fusion between filaments and also between fiber bundles was severe, thus good fibers could not be obtained.

## APPLICATION EXAMPLE 3

Composite spinning was done similarly as in Application Example 2 using a sheath composition made from a copolymerized polyester consisting of 60 mol of TA, 100 mol of BD, 20 mol of sebacic acid, and 20 mol of isophthalic acid and having the properties described in Table 1, as well as 5 wt% of Surlyn 1555 and a core made from PET with  $[\eta]$  of 0.67, followed by similar drawing, shrinking, crimping and cutting to obtain good fibers without any problems.

This composite fiber and PET fiber formed a high-strength nonwoven fabric with a breaking length of 4.0 km without any problems.

### COMPARATIVE EXAMPLE 3

Composite spinning was carried out similarly as in Comparative Example 2 using the copolymerized polyester of Application Example 3 alone as the sheath without the addition of the ionomer, and PET as the core. Fusion between individual filaments and between fiber bundles was substantial.

### APPLICATION EXAMPLE 4

Composite spinning was carried out using a sheath composition obtained by compounding the copolymerized polyester described in Table 1 with 3 wt% of Surlyn 1707 (ethylene copolymer containing about 5 mol% of methacrylic acid, with about 2/3 of the carboxy groups being neutralized by sodium) and using nylon 6 as the core at a core/sheath weight ratio=40/60, spinning head temperature of 270°C, and winding speed of 800 m/min, followed by drawing, shrinking, crimping, and cutting to obtain a good fiber without any problems.

This composite fiber and PET fiber formed a high-strength nonwoven fabric with a breaking length of 4.6 km without any problems.

### COMPARATIVE EXAMPLE 4

The composite spinning of Application Example 4 was repeated without the addition of the ionomer. Fusion between individual filaments was substantial, with some fusion between fiber bundles.

### APPLICATION EXAMPLE 5

Composite spinning was carried out using a sheath composition obtained by compounding the copolymerized polyester described in Table 1 with 7 wt% of Surlyn 1554 (ethylene copolymer with methacrylic acid, with neutralized zinc) and a polypropylene core at a core/sheath weight ratio = 40/60.

The spinning head temperature was 285°C with a winding speed of 800 m/min, followed by drawing, shrinking, crimping, and cutting to obtain a good fiber without any problems.

This composite fiber and PET fiber formed a high-strength nonwoven fabric with a breaking length of 3.2 km without any problems.

### COMPARATIVE EXAMPLE 5

The composite spinning of Application Example 5 was repeated without the addition of the ionomer. Fusion between individual filaments was substantial, with some fusion between fiber bundles.

#### APPLICATION EXAMPLES 6 AND 7

Good fibers and nonwoven fabrics were obtained without any problems using the sheath compositions described in Table 1 by composite spinning similarly as in Application Example 2, for obtaining fibers and nonwoven fabrics.

#### COMPARATIVE EXAMPLES 6 AND 7

Composite spinning was carried out similarly as in Application Example 6 or 7 without compounding the ionomer. Fusion between individual filaments occurred, with partial fusion between fiber bundles.

#### COMPARATIVE EXAMPLE 8

Pellets of the copolymerized polyester described in Table 1 were compounded with 5 wt% of sodium stearate, then melted and pelletized. The pellets were then re-melted and used as the sheath component in sheath-core composite spinning similarly as in Application Example 2. Smooth spinning could not be realized, due to occasional fiber breakage during spinning.

Also, at the stage of complete termination of the polymerization of the copolymerized polyester described in Table 1, 5 wt% of sodium stearate was added to the polymerization reactor, followed by stir mixing in vacuo under a nitrogen atmosphere, then extrusion and pelletizing. The pellets were then re-melted and used as the sheath component in sheath-core composite spinning similarly as in Application Example 2. Smooth spinning could not be realized, due to occasional fiber breakage during spinning.

#### COMPARATIVE EXAMPLES 9, 10, 11, AND 12

Using the sheath components described in Table 1, composite spinning was carried out similarly as in Application Example 2. Fusion between individual filaments and between fiber bundles occurred, thus good fibers could not be obtained.

#### COMPARATIVE EXAMPLE 13

Using the sheath component described in Table 1, composite spinning was carried out similarly as in Application Example 2, followed by formation of a nonwoven fabric from the resulting fibers. The fiber formation proceeded smoothly, but due to the high melting point of the copolymerized polyester and also the high temperature needed for bonding, the nonwoven fabric had a hard handle.

**COMPARATIVE EXAMPLE 14**

Using the sheath components described in Table 1, composite spinning was carried out similarly as in Application Example 2. While no fusion between individual fibers occurred, fiber breakage occurred from time to time. The nonwoven fabric obtained similarly as in Application Example 2 had a breaking length of only 0.7 km.

Table 1

| No.                      | Copolymerized polyester composition (mol%) |    |     |     |   |        |                  |        |                     |                   | [η]<br>(dl/g) | M.P.<br>(°C) | ΔH <sub>p</sub><br>(cal/g) | Crystallization speed |                 | SS<br>(kg/cm <sup>2</sup> ) | Compounded compound |           | Spinning<br>mode | Breaking<br>length of<br>nonwoven<br>fabric (km) |
|--------------------------|--|----|-----|-----|---|--------|------------------|--------|---------------------|-------------------|---------------|--------------|----------------------------|-----------------------|-----------------|-----------------------------|---------------------|-----------|------------------|--|
|                          | TA   | EG | BD  | HD  | Other aliphatic or alicyclic<br>component |        | Other component  |        | Temperature<br>(°C) | Time<br>(seconds) |               |              |                            | Name                  | Amount<br>(wt%) |                             |                     |           |                  |  |
|                          |  |    |     |     | Name                                      | Amount | Name             | Amount |                     |                   |               |              |                            |                       |                 |                             |                     |           |                  |  |
| Application<br>Example 1 | 60   | -  | 100 | -   | Sebacic acid                              | 40     | -                | -      | -                   | 1.10              | 153-<br>156   | 3.5          | Room<br>temperature        | 3                     | 14.0            | Surlyn<br>1555              | 5                   | Single    | 4.7              |  |
| Application<br>Example 7 | "  | "  | "   | "   | "   | "      | "                | "      | "                   | "                 | "             | "            | "                          | "                     | "               | "                           | "                   | Composite | 4.4              |  |
| Comparative<br>Example 1 | "  | "  | "   | "   | "   | "      | "                | "      | "                   | "                 | "             | "            | "                          | "                     | "               | "                           | "                   | Single    | -                |  |
| Comparative<br>Example 2 | "  | "  | "   | "   | "   | "      | "                | "      | "                   | "                 | "             | "            | "                          | "                     | "               | "                           | "                   | Composite | -                |  |
| Application<br>Example 3 | "  | "  | "   | "   | "   | 20     | Isophthalic acid | 20     | 1.04                | 150-<br>154       | 3.3           | 5.9          | 50                         | 20                    | 13.7            | Surlyn<br>1555              | 5                   | Composite | 4.0              |  |
| Comparative<br>Example 3 | "  | "  | "   | "   | "   | "      | "                | "      | "                   | "                 | "             | "            | "                          | "                     | "               | "                           | "                   | "         | -                |  |
| Application<br>Example 4 | 80   | 50 | 59  | -   | "   | "      | -                | -      | 0.73                | 144-<br>147       | 5.9           | 5.9          | 100                        | 50                    | 15.3            | Surlyn<br>1707              | 3                   | "         | 4.6              |  |
| Comparative<br>Example 4 | "  | "  | "   | "   | "   | "      | "                | "      | "                   | "                 | "             | "            | "                          | "                     | "               | "                           | "                   | "         | -                |  |
| Application<br>Example 5 | 75   | -  | -   | 100 | Adipic acid                               | 25     | -                | -      | 1.05                | 119-<br>123       | 6.0           | 6.0          | Room<br>temperature        | <5                    | 15.2            | Surlyn<br>1554              | 7                   | "         | 3.2              |  |
| Comparative<br>Example 5 | "  | "  | "   | "   | "   | "      | "                | "      | "                   | "                 | "             | "            | "                          | "                     | "               | "                           | "                   | "         | -                |  |

Table 1 (Continued)

| No.                       | Copolymerized polyester composition (mol%) |     |     |    |   |          |                  |        |        |                     | M.P.<br>(°C) | [η]<br>(dl/g) | η <sub>H<sub>2</sub>O</sub><br>(cal/g) | Crystallization speed |      | SS<br>(kg/cm²) | Compounded compound |     | Spinning<br>method | Breaking<br>length of<br>nonwoven<br>fabric (km) |
|---------------------------|--|-----|-----|----|---|----------|------------------|--------|--------|---------------------|--------------|---------------|--|-----------------------|------|----------------|---------------------|-----|--------------------|--|
|                           | TA   | EG  | BD  | HD | Other aliphatic or alicyclic<br>component |          | Other component  |        | Amount | Temperature<br>(°C) |              |               |  | Time<br>(seconds)     | Name |                | Amount<br>(wt%)     |     |                    |  |
|                           |  |     |     |    | Name                                      | Amount   | Name             | Amount |        |                     |              |               |  |                       |      |                |                     |     |                    |  |
| Application<br>Example 6  | 75   | -   | 90  | -  | Sebacic acid                              | 15       | Isophthalic acid | 10     |        |                     | 154-<br>159  | 1.12          | 5.2                                    | *                     | 3    | 13.7           | Surlyn<br>1555      | 2.5 | *                  | 3.8  |
| Comparative<br>Example 6  | *  | -   | *   | -  | *   | *        | *                | *      | *      | *                   | *            | *             | *                                      | *                     | *    | *              | *                   | *   | *                  | *  |
| Application<br>Example 7  | 100  | 35  | 55  | -  | triethylene glycol                        | 10       | -                | -      | -      | -                   | 162-<br>166  | 1.02          | 5.1                                    | 90                    | 40   | 12.0           | Surlyn<br>1555      | 5   | *                  | 2.5  |
| Comparative<br>Example 7  | *  | *   | *   | -  | *   | *        | -                | -      | -      | -                   | *            | *             | *                                      | *                     | *    | *              | *                   | *   | *                  | *  |
| Comparative<br>Example 8  | 60   | -   | 100 | -  | Sebacic acid                              | 40       | -                | -      | -      | -                   | 153-<br>156  | (1.10)        | 3.5                                    | Room<br>temperature   | 3    | 14.0           | Sodium<br>stearate  | 5   | *                  | -  |
| Comparative<br>Example 9  | 100  | -   | 60  | -  | diethylene glycol                         | 20       | Hydroquinone     | 20     |        |                     | 152-<br>155  | 0.74          | -                                      | -                     | -    | -              | Surlyn<br>1555      | *   | *                  | -  |
| Comparative<br>Example 10 | 50   | -   | 100 | -  | Sebacic acid                              | 50       | -                | -      | -      | -                   | 139-<br>144  | 1.05          | 1.6                                    | Room<br>temperature   | <7   | 14.5           | *                   | *   | *                  | -  |
| Comparative<br>Example 11 | 74   | -   | 39  | 50 | sebacic acid<br>cyclohexanedimethanol     | 26<br>11 | -                | -      | -      | -                   | 106-<br>110  | 1.22          | 1.2                                    | *                     | 32   | 12.8           | *                   | *   | *                  | -  |
| Comparative<br>Example 12 | 65   | -   | 90  | -  | sebacic acid<br>neopentyl glycol          | 10<br>10 | Isophthalic acid | 25     |        |                     | 147-<br>154  | 1.08          | 7.1                                    | 0-120                 | 90<  | 8.1            | *                   | *   | *                  | -  |
| Comparative<br>Example 13 | 80   | 100 | -   | -  | Sebacic acid                              | 20       | -                | -      | -      | -                   | 204-<br>206  | 0.72          | -                                      | -                     | -    | -              | *                   | *   | *                  | -  |
| Comparative<br>Example 14 | 70   | -   | 100 | -  | *   | 16       | Isophthalic acid | 15     |        |                     | 167-<br>172  | 0.33          | 6.2                                    | 60                    | 4    | 4.7            | *                   | *   | *                  | 0.7  |

Language Services Unit  
Phoenix Translations  
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